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Abundance of the magnificent sea anemone (*Heteractis magnifica*) and its marine ecotourism potential at Mu Ko Chumphon National Park, Thailand

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Abstract. Tourism at Mu Ko Chumphon National Park has been increasing attracting both Thai and international visitors; however, the number of visitors is still lower than the tourist carrying capacity of this area. Thus, tourism promotion is still needed to develop marine tourism in this area. Beside other marine organisms, the sea anemone, *Heteractis magnifica*, an invertebrate generally found in coral reefs having symbiotic relationships with an anemonefish, *Amphiprion* spp., can be used as a tourism attraction in Mu Ko Chumphon National Park. In this study, the abundance of *H. magnifica* from eight study sites at Mu Ko Chumphon National Park was investigated using a photo belt-transect method. Our results revealed that *H. magnifica* was found in all study sites, except for Ko Kula. The highest abundance of sea anemone *H. magnifica* was found in Ko Ngam Yai (5.15±0.30 ind./m^2), while the lowest coverage was found in Ko Mattra (0.09±0.02 ind./m^2). Besides, Ko Ngam Yai showed the highest abundance of anemonefish, *Amphiprion perideraion* (18.33 ind./m^2). Ko Ngam Yai and Ko Ngam Noi are suitable for snorkeling and SCUBA diving due to their high live coral cover and high diversity of macrofauna and fishes in these areas that can be potentially tourist attractions. Our study provides baseline data that can be further applied to tourism management strategies and tourism promotion at Mu Ko Chumphon National Park.

Keywords: management, marine ecotourism, Chumphon, sea anemone

1. Introduction

Sea anemones are important in benthic communities and play numerous roles such as predators, filter feeders, and prey. Some species can be opportunistic feeders with taking expediency of a variety of available food such as feeding on diatoms, eggs, and small crustaceans in the water column (Sebens, 1981; Shick 1991). Some sea anemones are active predators preying on echinoderms, cnidarians, and copepods (Dayton & Robilliard, 1970; Shick, 1991; Brueggeman, 1998; Amsler et al., 1999). Sea anemones may be vulnerable to physical conditions changes such as environmental stresses by anthropogenic disturbances and unpredicted climate change scenarios (Hayashi & Reimer, 2020).

Anemonefishes are habitat specialists that cannot be alive in nature without their host anemones, and limiting the anemone species that are available for sheltering (Fuatin, 1986). Twenty-eight species of anemonefishes have been reported (Robertson & Polunin, 1981), but there are only 10 species of host sea anemones, which this reason that can lead to intra- and interspecific competition (Mariscal, 1972; Dunn, 1981; Robertson & Polunin, 1981; Fuatin, 1985; Fuatin, 1986; Fuatin & Allen, 1997). Consequently, the areas where there is a high abundance of anemonefishes may not be enough host anemone species. Because of their uniqueness and beautifulness, sea anemones and anemonefishes are major resources for dive tourism (Flores-de la Hoya et al., 2018) and they are also risky to marine ornamentals trade (Shuman et al., 2005).

Tourism at Mu Ko Chumphon National Park, one of the tourist attractions in the western Gulf of Thailand, has been increasingly developed serving for both Thai and international tourists. The number of tourists visiting Chumphon Province increased from 1.36

million in 2016 to 1.52 million in 2019 (Ministry of Tourism and Sports, 2021), and the number of tourists visiting Mu Ko Chumphon National Park increased from 25, 000 in 2016 to 53,000 tourists in 2019 (Department of National Parks, Plant and Wildlife Conservation, 2021). However, the number of tourists visiting at these sites is lower than the estimated tourism carrying capacity; thus, tourism promotion and marketing at Mu Ko Chumphon is needed for tourism development to boost up local and national economy and to support well-being of local communities. Therefore, this study aimed to investigate the abundance of the sea anemone Heteractis magnifica and the abundance of anemonefish, *Amphiprion perideraion* in coral communities at Mu Ko Chumphon Marine National Park to understand their status and tourism potential.

2. Materials and Methods

2.1 Study sites

This study was conducted on coral communities in the Western Gulf of Thailand in March–May 2019. Mu Ko Chumphon National Park is a marine protected area, managed by the Department of National Parks, Plant and Wildlife Conservation. Mu Ko Chumphon National Park consisted of 40 nearshore islands in Chumphon Province in the Western Gulf of Thailand, which has a high potential for marine tourism development, particularly snorkeling and SCUBA diving. Eight reef sites in Mu Ko Chumphon National Park were observed including Ko Ngam Yai, Ko Ngam Noi, Ko Maphrao, Ko Raet, Ko Mattra, Ko Lawa, Ko Ranka Chio and Ko Kula. The coral communities at the study sites were in shallow water with the depth range of 1–8 m. Turbid water is generally found around Ko Maphrao as is influenced by high sediment load from the mainland.

2.2 Data collection

At each study site, the abundance of sea anemone, *H. magnifica*, in coral communities was recorded using photo belt-transect method (English et al., 1997), 30x1m transect, with three replicates. The abundance of anemonefish, *A. perideraion*, was recorded using fish-visual census method (English et al., 1997).

2.3 Statistical analysis

The abundance of sea ananemone, *H. magnifica*, and anemonefish, *A. perideraion*, was expressed in individuals per area unit (m^2). We tested the data for normality and homogeneity of variances and One-way Analysis of Variance (ANOVA) with Tukey's HSD was performed to detect the difference of abundance of *H. magnifica* and *A. perideraion* among study sites using R version 3.5.0.

Table 1. Location of study sites in Mu Ko Chumphon National Park with depth and the level of water turbidity

Station	Latitude	Longitude	Depth (m)	Turbidity
Ko Ngam Yai	10°29'34.13"N	99°25'7.85"E	3-5	Clear
Ko Ngam Noi	10°29'13.82"N	99°25'3.67"E	7-8	Clear
Ko Maphrao	10°23'25.79"N	99°17'31.06"E	1-2	High
Ko Raet	10°22'44.68"N	99°19'21.47"E	2-4	Moderate
Ko Mattra	10°24'06.96"N	99°21'05.22"E	2-5	Moderate
Ko Lawa	10°21'43.71"N	99°18'28.39"E	2-4	Moderate
Ko Ranka Chio	10°19'30.31"N	99°17'56.81"E	1-4	Moderate
Ko Kula	10°15'35.87"N	99°15'20.99"E	2-7	Moderate

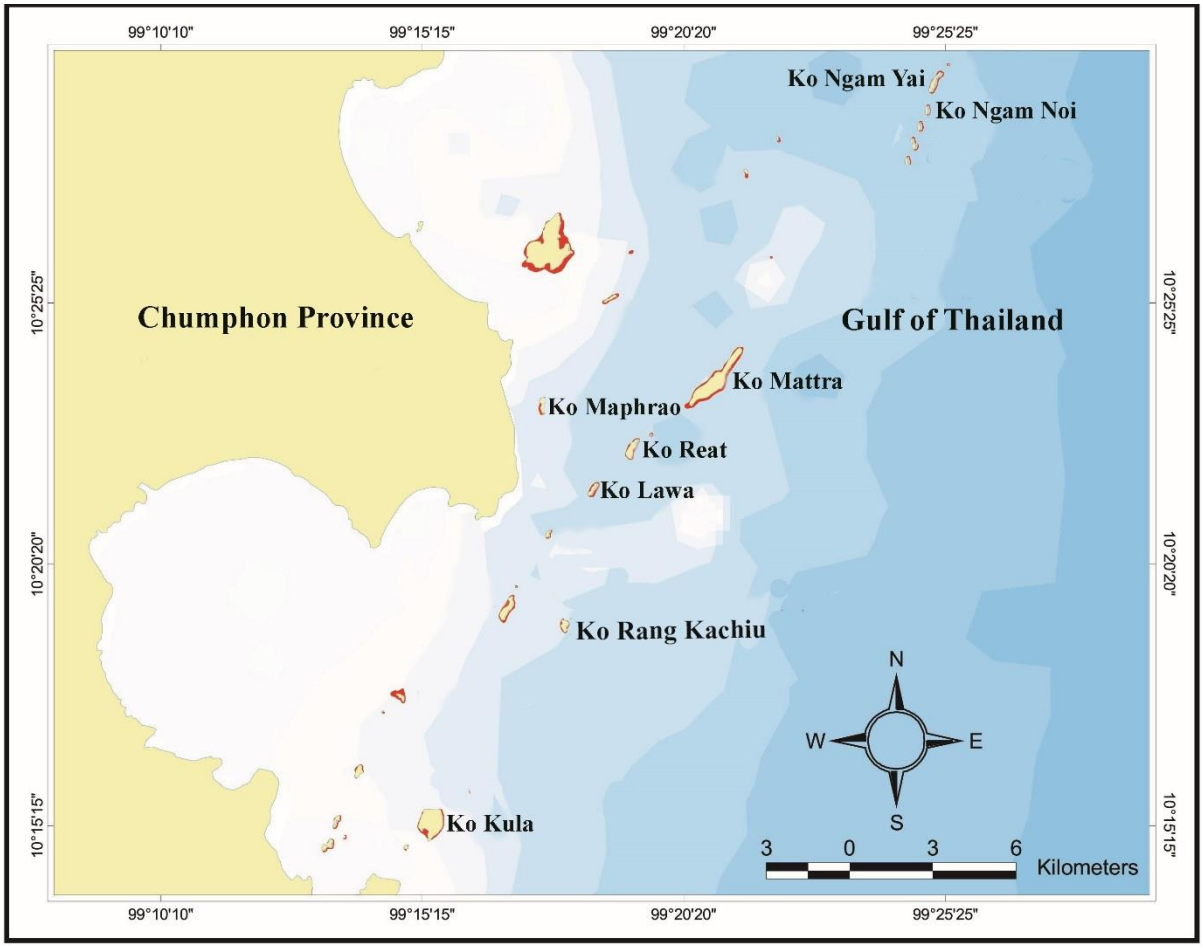

Figure 1. Location of study sites at Mu Ko Chumphon

3. Results

Our results revealed that the *H. magnifica* was found in all study sites, except for Ko Kula. The highest abundance of sea anemone *H. magnifica* was found in Ko Ngam Yai (6.91±0.32 ind./m^2), while the lowest one was found in Ko Maphrao (0.09 ± 0.02 ind./m^2). The abundance of sea anemone at Ko Ngam Yai was significantly different (F=86.53, p=0.001) from other sites. Low abundances of sea anemone were found at Ko Ngam Noi, Ko Maphrao, Ko Reat, Ko Mattra and Ko Kula ranging from 0±0.00 to 0.36±0.10 ind./m^2 . The abundances observed at Ko Lawa (2.67± 0.73 ind./m^2) and Ko Rangka Chio (1.82± 0.63 ind./m^2) were not statistical different (Fig. 2, Table 2).

In terms of anemonefish abundance, Ko Ngam Yai showed the highest abundance of anemonefish, *A. perideraion* (13. 87±6.74 ind./m^2) and it was significantly different from other study sites (F=8.35, p=0.001) (Fig. 3, Table 3). The anemonefish was found with low abundances at Ko Ngam Noi (0.27 ± 0.25 ind./m^2), Ko Lawa (0.14 ± 0.09 ind./m^2), and Ko Rangka Chio (0.15 ± 0.09 ind./m^2) with no statistical difference (p>0.05). None of *A. perideraion* was found at Ko Maphrao, Ko Reat, Ko Mattra and Ko Kula.

Ko Ngam Yai exhibited the highest proportion of fish and sea anemone, whereas the proportions at other sites remain low, particularly Ko Lawa and Ko Rangka Chio in which the abundances of sea anemone were relatively high with low fish abundances. The sea anemone was found at Ko Maphrao, Ko Reat, Ko Mattra; however, none of the anemonefish was found. Only Ko Kula had neither of the sea anemone and the anemonefish. The abundance of anemonefish was positively correlated with the abundance of sae anemone (r = 0.81, t = 6.50, p<0.001). Based on our study, Ko Ngam Yai showed the highest potential for promoting marine tourism

because they had the highest abundances of both anemonefish and sea anemone. Even though Ko Ngam Noi had the lower abundances of sea anemone and anemonefish, it is located close to Ko Ngam Yai; thus, it can be included in a tourism promotion program. The beautiful underwater scenery exhibiting at Ko Ngam Yai and Ko Ngam Noi are shown in figure 4.

4. Discussion

The sea anemone, *H. magnifica* and the anemonefish, *A. perideraion* were found in Ko Ngam Yai with the highest densities compared with those found at other study sites. It might because of that the sea water at Ko Ngam Yai is clear. It is located quite far from the shore receiving less pollution from the mainland. Sea anemones are generally found in the areas with clear water as well as the temperature is an important factor for sea anemones distribution (Rifa'i, 2016). Sebens (1980) has been reported that food availability, water depth, and temperature are influential factors in the reproductive mechanism of sea anemones. In subtropical eastern Australian waters, the distribution and abundance of giant anemones are influenced by water temperature, wave disturbance and water depth. The deep-reef habitats may be less vulnerable to disturbance events such as warm-water and storms as well as the distance from the shoreline is advantaged to avoid anthropogenic pollution. (Glynn, 1996; Riegl & Piller, 2003; Bongaerts et al., 2010).

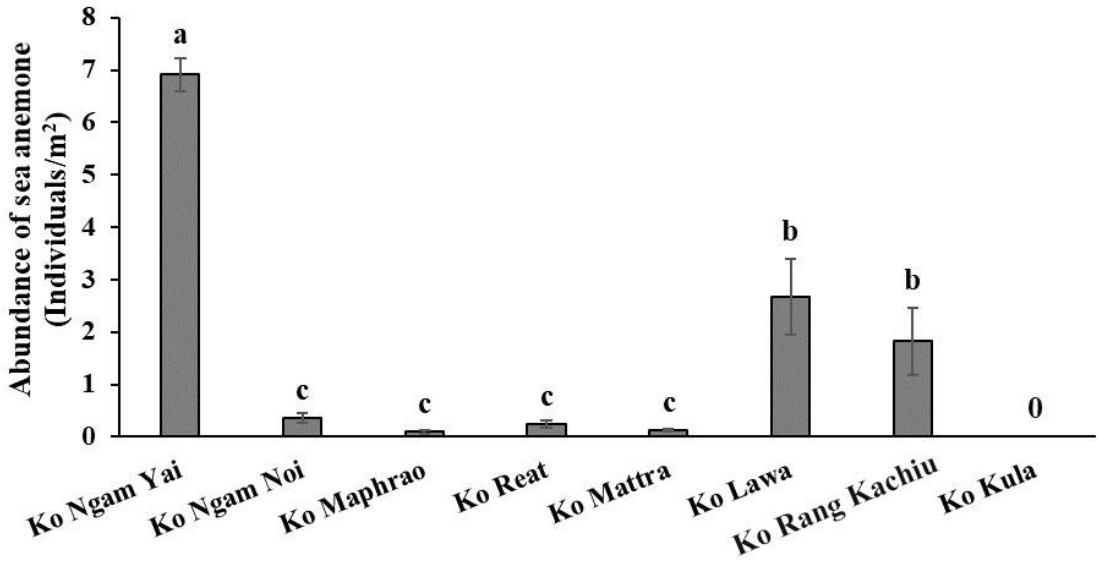

Figure2. Abundance of sea anemone at each study site

Table 2. Results of one-way analyses of variance (ANOVA) and the multiple comparison illustrating the significance of differences in sea anemone abundance among study sites

Source of variation	df	Sum square	Mean square	*F*	*P*
One-way ANOVA test					
Station	7	129780	18539.9	86.534	<0.001***
Within station	16	3428	214.2		
Total	23				

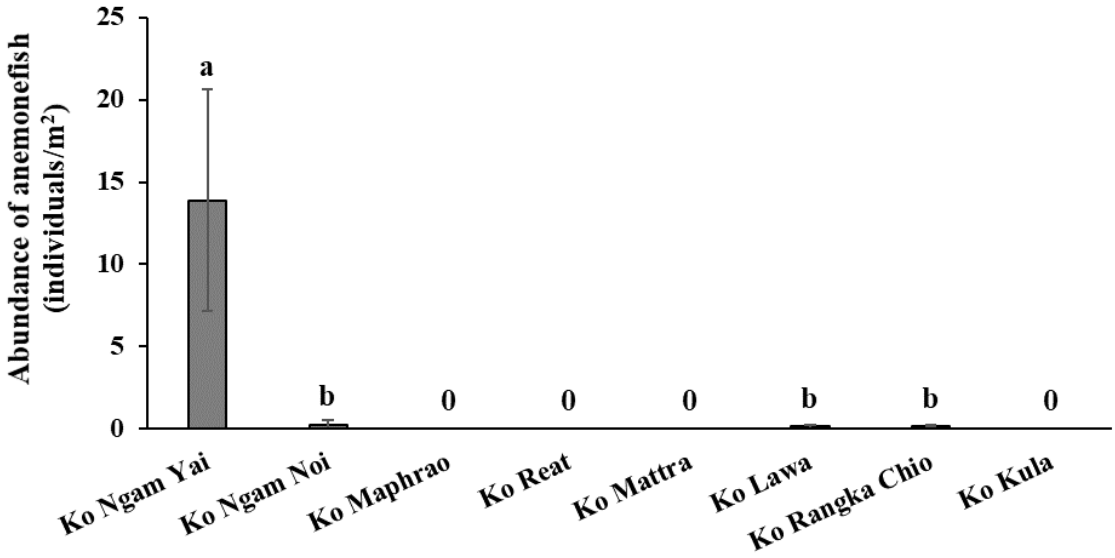

Figure 3. Abundance of anemonefish at each study site

Table 3. Results of one-way analyses of variance (ANOVA) and the multiple comparison illustrating the significance of differences in anemonefish abundance among study sites

Source of variation	df	Sum Square	Mean Square	*F*	*P*
One-way ANOVA test					
Station	7	499.12	71.03	8.35	<0.001***
Within station	16	136.53	8.53		
Total	23				

Sea anemones and anemonefish population are highly threatened by aquarium collectors (Shuman et al., 2005); however, the remote and inaccessible nature of mesophotic coral ecosystems makes this threat unlikely to affect their abundance in these habitats. In Thailand, sea anemones have been protected by Wildlife Conservation and Protection Act B.E. 2532 (1992) and most coral communities are in the national parks where fishing and harvesting marine organisms are prohibited, according to the National Park Act B.E. 2562 (2019).

Our results showed that the high abundance of the anemonefish was related to the high abundance of *H. magnifica*. Because of its mutualism, conserving sea anemones is highly required for conserving anemonefishes due to their mutualism relationship.

As mentioned earlier, Ko Ngam Yai and Ko Ngam Noi have a high potential for marine tourism in this area since they are suitable for snorkeling and SCUBA and have a high live coral cover that dominating with branching corals (*Acropora* spp.) and high diversity of macrobenthos and reef fishes in these areas included sea urchin *Diadema setosum*, soft corals (*Sarcophyton* sp.), mushroom anemones (*Discosoma rhodostoma*), and silver demoiselle (*Neopomacentrus anabatoides*) (Sutthacheep et al., 2018; Sutthacheep et al., 2019). Moreover, the tourism carrying capacity in these areas was lower than the number of visitors that visited in Mu Ko Chumphon (Yeemin et al., unpublished) in which marine tourism can be promoted and developed. However, tourism must be developed sustainably with sustainable approaches such as sustainable tourism, ecotourism, etc. in order to minimize pollution, particularly solid waste and wastewater and other impacts from tourism activities (Huang & Coelho, 2017). Our results provide a database supporting the formulation of tourism management strategies and tourism promotion at Mu Ko Chumphon.

Figure 4. Underwater photographs of sea anemone and anemonefish at study sites

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